FUNCTIONAL MAGNETIC RESONANCE IMAGING CONTRIBUTION TO LANGUAGE AREAS ASSESMNENT IN CHILDREN WITH NON-LESION FOCAL EPILEPSY

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ABSTRACT

Functional Magnetic Resonance Imaging (fMRI) is one of the newest areas of medical imaging which evaluates the activation of different zones in the brain during the acquisition of brain images by functional magnetic resonance. One of the applications of fMRI is the assessment of language area. In this article we summarize the most important data related to fMRI in the language assessment and we illustrate with a clinical case of a girl with symptomatic epilepsy secondary to a dual pathology of temporal lobe in the dominant cerebral hemisphere (tumour and dysplastic lesion), in which the use of this method helped at presurgical planning.

Keywords: functional MRI, language area, astrocitom, video-EEG

INTRODUCTION

Neuroscience is a discipline dedicated to the study of the structure and normal function of central nervous system and integrates the results in the field of pathology, with the aim of understanding the complex mechanisms underlying brain activity. Because the brain anatomic study could be performed post-mortem without particular problems as any other part of the body, remains the problem of brain function which can be evaluated only in vivo. For understanding the cerebral function, different methods were designed, initial invasive and after the appearance of functional Magnetic Resonance imaging (fMRI) also non-invasive.

fMRI is one of the newest areas of medical imaging that combines data taken from images acquired by clasical magnetic resonance with some during metabolic changes that occur in brain areas activated by different methods.

Classic MRI uses a powerful magnetic field, with pulse from radio frequency and a computer for detailed analysis of images of various organs, soft tissues, bones and virtual of other internal human organs.

While performing fMRI, different activation methods are made increasing the metabolic activity in brain areas responsible for the function performed for 30 seconds, then followed by a pause for 30 seconds (which are control images). Thus, the patient will be asked to perform different activities, like joining the thumb with the fingers of the same hand, breaking a sheet or answering some simple questions. All these activities will be followed by a pause during which the patient is asked to stand still.

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Thus, to perform functional MRI, is necessary to colaborate with the technician and the doctor, so the sedation of the patient can't be used, not even the mild one. These details lower the degree of application of the method and also the adresability only for children over a certain age and in all cooperative patients, usually with normal intelect.

BOLD tehnique (blood oxygen level-dependent functional magnetic resonance) is based on detecting rapid variations of oxygenation and cerebral perfusion during neuronal activation. Since hemoglobin has different magnetic signal depending on the condition of oxygen, during fMRI occur activations in different cerebral areas. Using a statistical difference signal between the state of activation and control state, a map activation of the principal functional zones of the brain is created. It will be validated as real only the positive area and removed the false positive and negative (Figure 1).

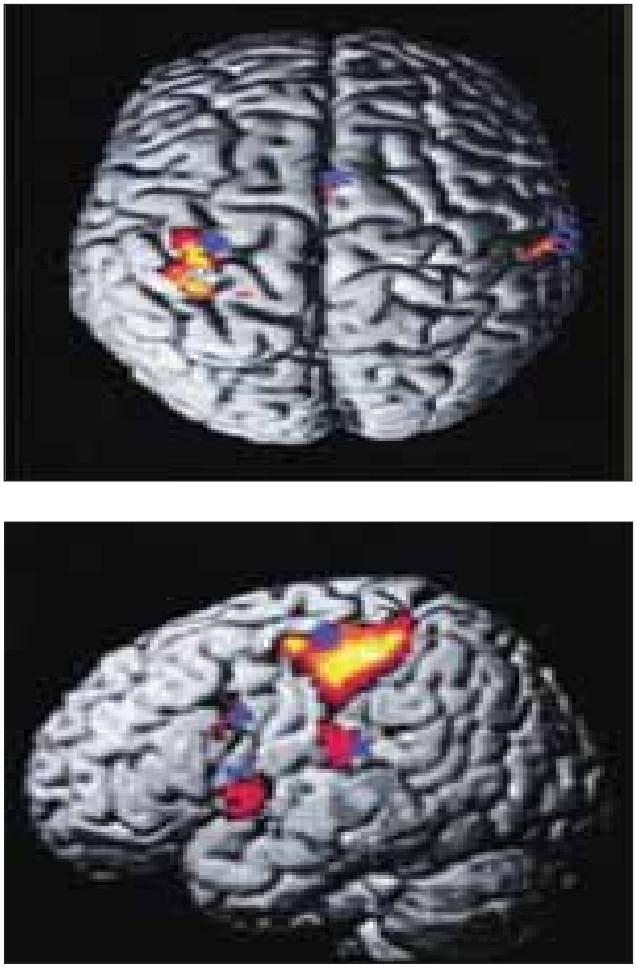


Figure 1. *fMRI images showing activation of areas responsible for language and for the area of primary motor cortex*

Thus, fMRI is an indirect, non-invasive method which measures the neuronal activity and helps us to perform a,,brain maping'' to determine the brain areas involved in functions such as memory, language, motor and sensitivity. So, it have been studied: visual system (identification of primary visual cortex and visual associative areas, retinoic-optic organization, oculomotricity, mental imaging), motor and sensitive system (primary and association motor and sensitive areas, basal nucleus activation during motor gestures), auditory system, vestibular, localization and activation of cortical cognitive areas (language, long-term memory, reasoning etc). fMRI allows noninvasive and in the dynamics study of normal and pathological brain development in children, understanding neural plasticity of the brain, especially after extended, irreversible injuries.

Thus, once these understood, we can assess the effect of the brain damage secondary to strokes, traumatic injuries or degenerative diseases or we can predict the effects of interventional therapy, helping us in planning neurosurgery intervention or radiotherapy.

There are risks of false positive or negative due to time factor, in the cases of analysis of data not in the real time of activation but later so that the area that appears activated is not primary but one adjacent to it.

We can say that that this method is new, experimental, and often requires additional pre or intraoperative tests for precise evaluation of brain areas described as being active during fMRI.

Using fMRI is validated for assessing the language and motor area, so it can replace invasive tests as WADA. Assessment of language area is crucial in the surgical intervention of epilepsy patients with epileptogenic focus in the speech area.

CASE STUDY

Aura is a five years old girl with normal intellect, which comes in paediatric neurology department for paroxysmal events since the age of 4 years and 6 months. The events appeared both in awaking and in sleep period, sometimes with epigastric rising sensation, nausea, vomiting, fear, drooling, oro-alimentary automatisms, often with loss of consciousness sometimes with secondary generalization as tonic-clonic generalized seizures, lasting 2-3 minutes, followed by post critical sleep. The events have a daily frequency of 2-3 per day.

Psychomotor development was normal, personal physiological and family history was insignificant.

Somatic and neurological examination upon admission was normal, but parents have noticed a loss of cognitive abilities as short-time memory (she saw her aunt an hour ago and not remember it).

Clinical data exclude a lot of nonepileptic paroxysmal cerebral events in awake as tics (lost of consciousness, the manifestations appeared also in sleep), transient ischemic attacks (short-duration events), alternating hemiplegia of the childhood (short attacks without motor deficit), benign paroxysmal torticollis (attacks are accompanied by loss of consciousness), pseudocrisis (manifestation in wakefulness and sleep) or nocturnal events (night terror, sleep walking), these are excluded because the events occur both in wakefulness and in sleep.

Being raised the suspicion of epileptic seizures, a routine EEG recording was recommended with hyperventilation and intermittent light stimulation, but because it was normal video-EEG monitoring was performed to record the events and their details.

Prolonged EEG showed normal background rhythm but intricate with epileptiform discharges, as spikes and sharp waves in the left temporal derivations (Figure 2) and sometimes generalized discharges (Figure 3).

We record a seizure during wakefulness. Aura felt,,something'' (she can't describe it and during the seizure she was alone in the room), followed by automatisms with her left hand, clonic movements of the right hand and then followed by a postictal nose wiping, initially with the right hand and then with the left. The seizure was during one minute without postcritical phenomena. Consciousness wasn't tested, recalling that the girl was alone during the crisis.

Ictal EEG showed initially rhythmic delta rhythm in T3 derivations (Figure 4), followed by migration in the whole left hemisphere. Due to the movement during the seizure an artifact appeared in the Fp1 electrode (Figure 5).

After video-EEG recording of the event, focal epilepsy is diagnosed and for clarify the etiology is recommended brain MRI. Imagistic exam showed a lesion in the left temporal lobe, with hyper signal Flair aspect and didn't enhance. The lesion seemed to be dual with one in the right mesial area better delimited, circular, surrounded by a more diffuse area of modified signal (Figure 6 – Brain MRI).

Using the anamnesis, clinical and laboratory data with the registration of the events (EEG-epileptiform discharges,) and also brain MRI-lesion in the left temporal lobe, Aura was diagnosed with symptomatic focal epilepsy-left temporal lobe seizures.

Antiepileptic treatment with carbamazepine, oxcarbazepine, valproate, lamotrigine was tryied, all in therapeutic doses, in monotherapy and in association, but after six months the crisis persisted and the cognitive capacities declined.

Given the lesion shown on brain MRI (extensive lesion on the left temporal lobe)and the onset of the seizures in the lesion area (clinical data – epigastric rising sensation, automatisms with the left hand

Figure 2. *Interictal EEG-T3 spikes*

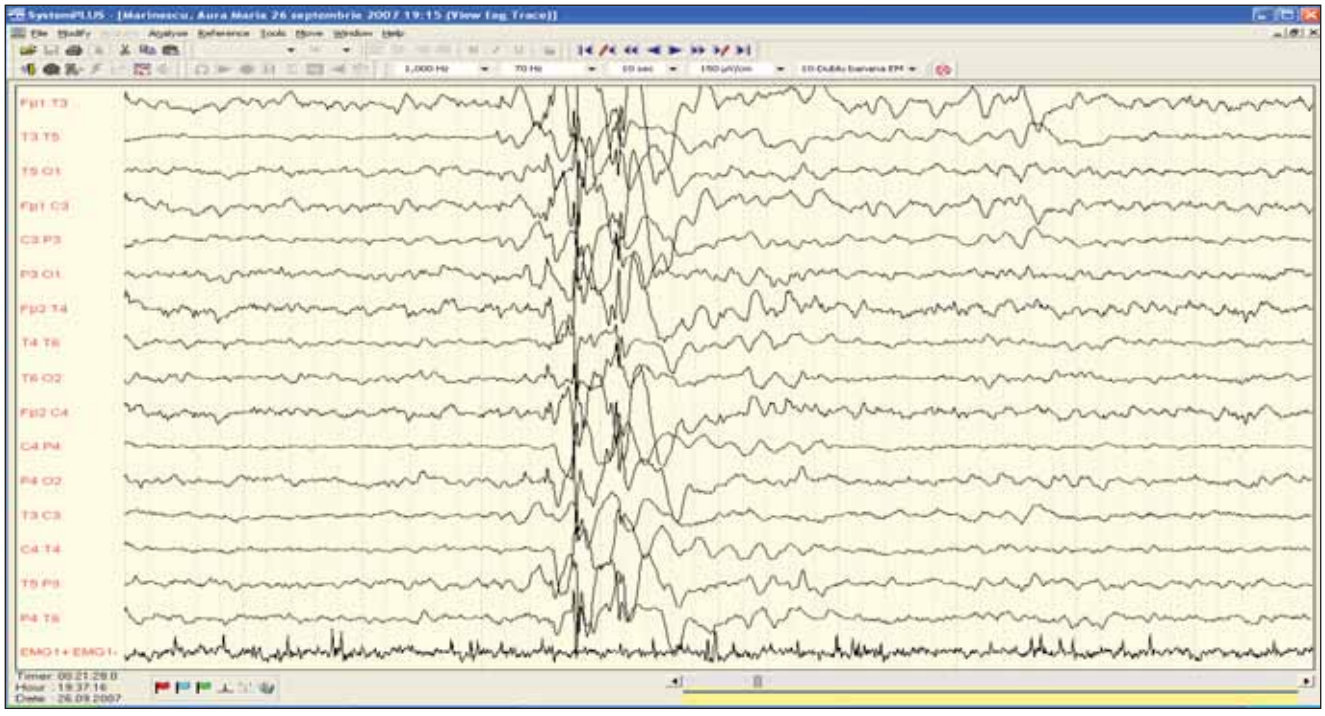


Figure 3. *Interictal EEG – generalized epileptiform discharges*

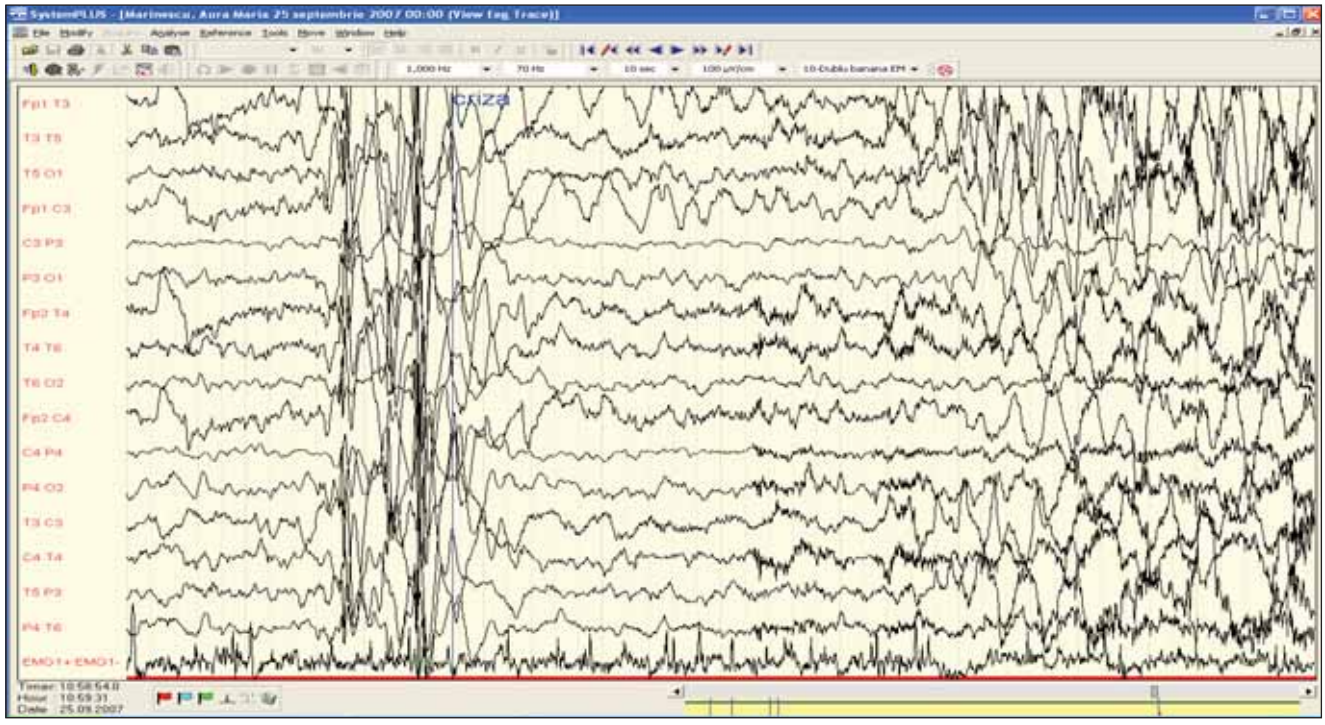


Figure 4. *Ictal video-EEG recording – debut of crisis with slower rhythm in T3*

and also the EEG data – ictal rhythm on the left temporal derivations; also interictal epileptiform discharges in the same side) and because seizures were resistant to treatment, we concluded that it is a direct link between the brain lesion and the seizures and the question of neurosurgical indication was raised.

Because Aura is right handed and the lesion is very extensive infiltrattive in the left temporal lobe, the implication of language could be possible or damaged during surgery, though assesing the language area could be usseful.

It was performed fMRI for language are, using 1.5 T GE, echo-speed Signa LX, and the language

***Figure 5**. Ictal registration – rhythmic delta rhythm in left derivations*

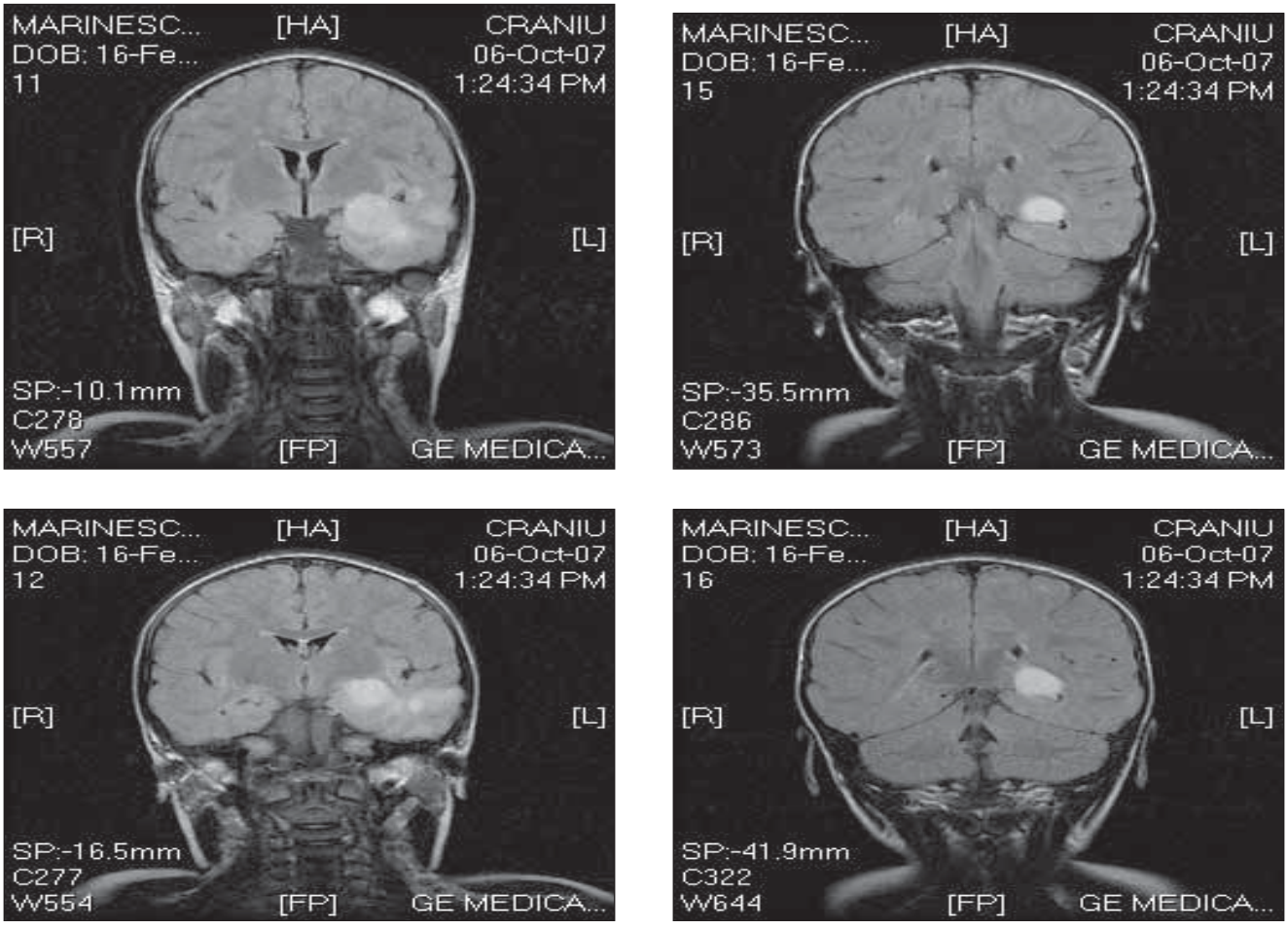
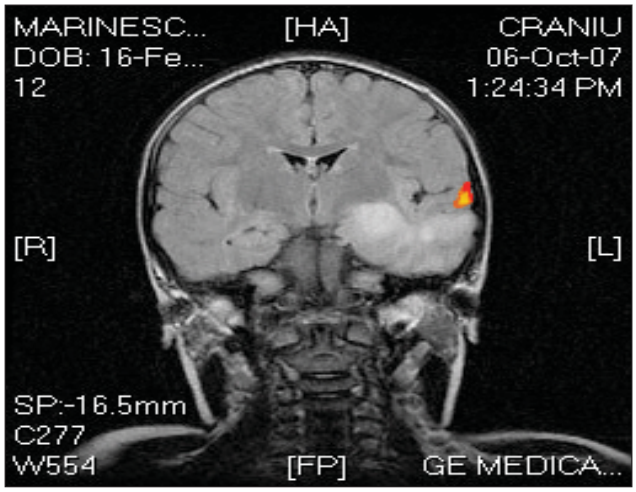


***Figure 6.** Brain MRI*

area was evidenced by activating areas through,,verb generation'' method (a noun is indicated and the girl associates a verb). Investigation results showed that the left hemisphere is dominant, but the language area is above the lesion (Figure 7).



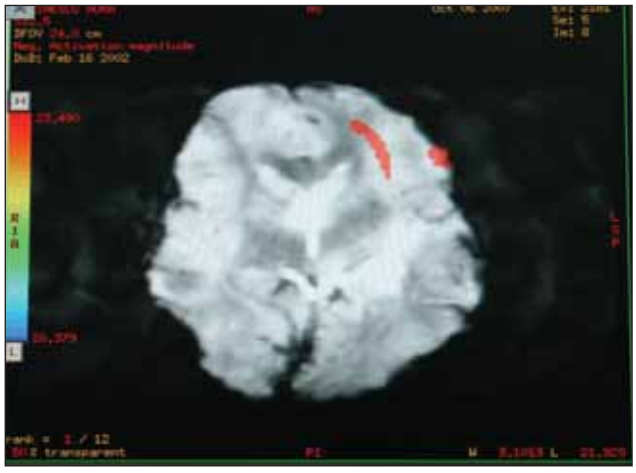


Figure 7. *Functional MRI showed the language area is the left hemisphere, in the temporal lobe above the lesion*

Full removal of the lesion was performed-approximately two thirds of the temporal lobe. Pathological diagnosis was low grade astrocitom. The migrational disorder seen on MRI was not mentioned by morphopathologic exam.

The patient is currently under antiepileptic treatment with oxcarbazepine and lamotrigine without seizures, with preserved language but with cognitive and memory disturbances.

DISCUSSION

Doctors recommend fMRI to achieve functional mapping of the cerebral cortex and to face with the results of other techniques: WADA, PET, SPECT, EEG, evocated potentials, having good results with a spatial and temporal resolution.

fMRI is an important method for language study in adults since 1997, and in 1999 was introduced also for children. Functional MRI's applications for language in children offers multiple potential for the assessment of a complex cerebral pathologies, because language is one of the early markers for the existance of brain disorders associated with mental retardation or regression. This detail highlights the importance of understanding the correlation between language and various pathologies or in normal children.

Different methods were used for language assessment by fMRI, methods which evaluates mostly word fluency. This has been extensively studied in adults and it showed activation of the inferior frontal gyrus, dorsolateral prefrontal cortex, superior temporal gyrus, medial temporal gyrus and cingulate gyrus. Frontal and temporal activations are described as prevalent on the left side.

Different methods of evaluation of word fluency have been successfully used in children, most frequently is verb generation test. This method was introduced by Peterson in 1988 and involves the combination of a verb to a given noun. Lateralization model to the left both in the temporal and frontal lobes is similar to the adult.

Functional MRI is an investigation in development, which improves from day to day.

Although considered to be as accurate in locating brain functional areas like any other method, this method has less experience than other MRI techniques. Thus, doctors may recommend additional tests to confirm the results of functional MRI's if the results help in making critical decisions (like planning steps of neurosurgical intervention).

PARTICULARITY OF THE CASE

As we know, this is the first case of fMRI for language area in children published in Romania. Is a national news because of the performed technique by using functional magnetic resonance imagery and because it was made to a child only five years old.

This case of symptomatic focal epilepsy is proof of the necessity for better interdisciplanary collaborations with the aim of better therapeutic results.

Aura was diagnosed and monitored from the clinical and electroencephalographic point of view by a pediatric neurolologist. Because a lesion near the language area was observed through a classical MRI and a surgical intervention was reccomended, a fMRI was also performed. This technique was done by associating a verb to a given noun, with the help of a doctor who stayed with the girl in the magnetic room and reproduced different nouns known by the girl, and she associated them with a verb (for example food-eat).

Activation techniques have lasted 30 seconds folowed by a period in which the girl stand still for 30 seconds, then the maneuvers were redone, all the activations over a period of approximately 20 minutes. The images were acquired and analyzed by a physicist and reviewed by a radiologist. The neurosurgeon operated the girl with good results, with seizures control, but with cognitive impairment which we believe that the patient had it and probably would have increased anyway in time.

In the present, approximately one year after surgery, she is without seizures, under antiepileptic treatment with 2 antiepileptic drugs, without epileptiform discharges on EEG, with cognitive impairment, but not very big, being trained in I class.

We did considered important presenting this new investigation in Romania, where Wada test can't be performed, and this could be the only possibility for the assessment of dominant hemisphere and language area.

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